WHAT IS CLAIMED IS:

1. An imaging method for detecting misalignment of two periodic structures placed next to each other with respect to a reference plane, comprising:

providing radiation to illuminate the two periodic structures;

collecting radiation from the two structures and directing the collected radiation to form an image of at least portions of the two structures on an array of detectors; and

determining a misalignment between the structures from outputs of the detectors.

2. The method of claim 1, wherein said determining includes finding a phase difference between outputs of the detectors.

3. The method of claim 1, wherein said providing provides a beam of radiation so that the beam illuminates the structures along directions that are substantially normal or near normal to the reference plane.

4. The method of claim 3, wherein the collecting collects radiation from the two structures along directions at oblique angles to the reference plane.

5. The method of claim 1, wherein said providing provides a beam of radiation so that the beam is at an oblique angle to the reference plane.

6. The method of claim 5, wherein the collecting collects radiation from the two structures along directions that are substantially normal or near normal to the reference plane.

7. The method of claim 1, wherein said providing provides a beam of radiation that illuminates the entire extent of both structures simultaneously.

8. The method of claim 1, each of said structures comprising an array of lines, said method further comprising summing the outputs of the detectors detecting radiation imaged onto the detectors from a line of one of the structures.

9. The method of claim 1, said two structures being periodic substantially along a direction, wherein said determining includes cross-correlating intensities of the radiation detected from adjacent lines of the two structures across at least two or more of the lines of each of the structures.

10. The method of claim 1, wherein said providing provides a laser beam or a broadband beam having multiple wavelengths.

11. The method of claim 10, wherein said providing provides a laser beam and said collecting collects radiation only along directions away from a specular reflection direction of the laser beam with respect to the reference plane.

12 The method of claim 1, wherein said collecting collects radiation from the structures only along one or more directions away from any specular reflection direction(s) of the beam.

13. A method for detecting misalignment of two structures placed next to each other with respect to a reference plane, comprising:

providing a beam of radiation to illuminate a portion of each of the two structures;

collecting radiation from the illuminated portion of each of the two structures and directing the collected radiation from each structure to a corresponding detector through a corresponding one of two apertures; and

determining a misalignment between the structures from outputs of the detectors.

14. The method of claim 13, further comprising causing relative motion between the apertures and detectors on one hand and the two structures on the other, or between the beam on one hand and the two structures on the other.

15. The method of claim 13, wherein said collecting and directing employ optics, further comprising locating said apertures so that the image of each of the two structures is focused by the optics substantially to the corresponding aperture.

16. An imaging apparatus for detecting misalignment of two periodic structures placed next to each other with respect to a reference plane, comprising:

a source providing radiation illuminating the two periodic structures;

an array of detectors;

optics collecting radiation from the two structures and directing the collected radiation to form images of at least portions of the two structures on the array of detectors which provide outputs; and

a processor determining a misalignment between the structures from a phase difference between the outputs of the detectors.

17. The apparatus of claim 16, wherein said array includes a two dimensional array of detectors.

18. The apparatus of claim 16, wherein said source provides a beam of radiation so that the beam illuminates the structures along directions that are substantially normal or near normal to the reference plane.

19. The apparatus of claim 18, wherein the optics collects radiation from the two structures along directions at oblique angles to the reference plane.

20. The apparatus of claim 16, wherein said source provides the beam so that the beam is at an oblique angle to the reference plane.

21. The apparatus of claim 20, wherein the optics collects radiation from the two structures along directions that are substantially normal or near normal to the reference plane.

22. The apparatus of claim 16, wherein said source provides a beam of radiation that illuminates the entire extent of both structures simultaneously.

23. The apparatus of claim 16, each of said structures comprising an array of lines, said processor summing the outputs of the detectors detecting radiation imaged onto the detectors from a line of one of the structures.

24. The apparatus of claim 16, said two structures being periodic substantially along a direction, wherein said processor cross-correlates intensities of the radiation detected from adjacent lines of the two structures across at least two or more of the lines of each of the structures.

25. The apparatus of claim 16, wherein said source provides a laser beam or a beam having multiple wavelengths.

26. The apparatus of claim 25, wherein said source provides a laser beam and said optics collects radiation only along directions away from a specular reflection direction of the laser beam with respect to the reference plane.

27. The apparatus of claim 16, wherein said optics includes a refractive element that directs radiation from the source to the two structures and that collects radiation from the two structures.

28. The apparatus of claim 27, said refractive element having a numerical aperture in the range of about 0.1 to 0.9.

29. The apparatus of claim 28, said refractive element having a numerical aperture in the range of about 0.4 to 0.8.

30. The apparatus of claim 29, said refractive element having a numerical aperture in the range of about 0.5 to 0.7.

31. The apparatus of claim 16, said detectors having an integration time less than about 10 milliseconds.

32. The apparatus of claim 16, said source providing a beam of radiation to illuminate the structures, wherein said optics collects radiation only along one or more directions away from any specular reflection direction of the beam from the reference plane

33. The apparatus of claim 16, said source providing a beam of radiation to illuminate the structures, wherein said optics collects radiation along one or more specular reflection directions of the beam from the reference plane.

34. An apparatus for detecting misalignment of two structures placed next to each other with respect to a reference plane, comprising:

a source providing a beam of radiation to illuminate a portion of each of the two structures;

one or more detectors;

two apertures;

optics collecting radiation from the illuminated portion of each of the two structures and directing the collected radiation from each structure to a corresponding detector through a corresponding one of the two apertures, causing the corresponding detector to provide an output; and

a processor determining a misalignment between the structures from output(s) of the detector(s).

35. The apparatus of claim 34, further comprising an instrument causing relative motion between the apertures and detectors on one hand and the two structures on the other, or between the beam on one hand and the two structures on the other.

36. The apparatus of claim 34, wherein said optics causes the image of each of the two structures to be focused substantially to the corresponding aperture.

37. An imaging apparatus for detecting misalignment of two structures placed next to each other with respect to a reference plane, comprising:

a source providing a beam of radiation illuminating the two structures;

one or more detectors;

optics collecting radiation from the two structures and directing the collected radiation to the one or more detectors which provide outputs, said optics having a numerical aperture in the range of about 0.1 to 0.9; and

a processor determining a misalignment between the structures from outputs of the detectors.

38. The apparatus of claim 37, said optics having a numerical aperture in the range of about 0.4 to 0.8.

39. The apparatus of claim 38, said optics having a numerical aperture in the range of about 0.5 to 0.7.

40. The apparatus of claim 37, wherein said one or more detectors include a CCD detector.

41. The apparatus of claim 37, said one or more detectors having an integration time less than about 10 milliseconds

42. The apparatus of claim 37, said source providing pulses of radiation illuminating the two structures, wherein at least one of the pulses has a pulse width less than about 10 milliseconds.

43. The apparatus of claim 42, said source comprising a mechanical shutter with aperture time of less than about 10 milliseconds.

44. The apparatus of claim 37, further comprising a mechanical shutter with aperture time of less than about 10 milliseconds in an optical path between the structures and the one or more detectors..

45. An imaging method for detecting misalignment of two structures placed next to each other with respect to a reference plane, comprising:

providing a beam of radiation illuminating the two structures;

providing one or more detectors;

using optics to collect radiation from the two structures and direct the collected radiation to the one or more detectors which provide outputs, said optics having a numerical aperture in the range of about 0.1 to 0.9; and

determining a misalignment between the structures from outputs of the detectors.

46. The method of claim 45, wherein said using uses optics having a numerical aperture in the range of about 0.4 to 0.8.

47. The method of claim 46, wherein said using uses optics having a numerical aperture in the range of about 0.5 to 0.7.

48. An imaging apparatus for detecting misalignment of two structures placed next to each other with respect to a reference plane, comprising:

a source providing a beam of radiation illuminating the two structures;

one or more detectors having an integration time less than about 10 milliseconds;

optics collecting radiation from the two structures and directing the collected radiation to the one or more detectors which provide outputs; and

a processor determining a misalignment between the structures from outputs of the detectors.

49. An imaging apparatus for detecting misalignment of two structures placed next to each other with respect to a reference plane, comprising:

a source providing pulses of radiation illuminating the two structures, wherein at least one of the pulses has a pulse width less than about 10 milliseconds;

one or more detectors;

optics collecting radiation from the two structures and directing the collected radiation to the one or more detectors which provide outputs; and

a processor determining a misalignment between the structures from outputs of the detectors.

50. The apparatus of claim 49, said source comprising a mechanical shutter with aperture time of less than about 10 milliseconds.

51. An integrated processing and imaging apparatus for processing a sample having two structures, comprising:

(a) an imaging system for detecting misalignment of the two structures placed next to each other with respect to a reference plane, said system comprising:

a source providing a beam of radiation illuminating the two structures;

optics collecting radiation from the two structures and directing the collected radiation to the one or more detectors to form images of at least portions of the two structures on the detectors, which provide outputs; and

a processor determining a misalignment between the structures from outputs of the detectors; and

(b) a processing system processing said sample, said processing system responsive to the misalignment for adjusting a processing parameter.

52. The apparatus of claim 51, said optics having a numerical aperture in the range of about 0.1 to 0.9.

53. The apparatus of claim 52, said optics having a numerical aperture in the range of about 0.4 to 0.8.

54. The apparatus of claim 53, said optics having a numerical aperture in the range of about 0.5 to 0.7.

55. The apparatus of claim 51, said processing system including a stepper or an etcher for processing a semiconductor sample.

56. The apparatus of claim 51, wherein said one or more detectors include a CCD detector

57. The apparatus of claim 51, wherein said one or more detectors have an integration time less than about 10 milliseconds.

58. The apparatus of claim 51, said source providing pulses of radiation illuminating the two structures, wherein at least one of the pulses has a pulse width less than about 10 milliseconds.

59.The apparatus of claim 58, said source comprising a mechanical shutter with aperture time of less than about 10 milliseconds.

60. The apparatus of claim 51, further comprising a mechanical shutter with aperture time of less than about 10 milliseconds in an optical path between the structures and the one or more detectors..

61. The apparatus of claim 51, said processing system including a stepper or an etcher for processing a semiconductor sample.

62. The apparatus of claim 61, said source providing a beam of radiation to illuminate the structures, wherein said optics collects radiation only

along one or more directions away from any specular reflection direction of the beam from the reference plane

63. The apparatus of claim 51, wherein said optics collects radiation along one or more specular reflection directions of the beam from the reference plane.

64. A method for determining overlay errors from a target having two structures, comprising:

providing a two-dimensional image of the target;

deriving at least one one-dimensional signal from the image; and

determining an overlay error from the at least one signal.

65. The method of claim 64, wherein said determining employs non-linear regression.

66. The method of claim 65, further comprising providing a model that provides parameter values wherein said regression matches the at least one signal to the parameter values provided by the model.

67. The method of claim 66, wherein said target comprises two gratings adjacent to each other periodic along substantially the same direction, said model providing parameter values for determining value(s) for the pitches of the gratings and a phase shift between them.

68. The method of claim 66 said model employing a fast Fourier transform algorithm.

69. The method of claim 64, said structures comprising boxes or bars, wherein said deriving derives two one-dimensional signal from the image in reference to two axes of the two-dimensional image.

70. The method of claim 64, said at least one one-dimensional signal being an analytical function.

71. The method of claim 64, said at least one one-dimensional signal being an edge function.

72. A method for determining overlay errors from a target having two structures, comprising:

providing a two-dimensional image of the target;

representing the image by at least one signal which is an analytical function of position in the image; and

determining an overlay error between the two structures using a curve fitting process of the at least one signal to data on the structures from the image.

73. The method of claim 72, each of said structures being periodic and having a pitch, wherein the representing:

provides a one-dimensional signal corresponding to the pitch of each of the structures; and

deriving from said one-dimensional signal an altered one-dimensional signal corresponding to an average value of the pitches of the structures for each of the structures.

74. The method of claim 72, each of said structures being periodic along substantially a common direction and having a pitch, wherein the representing provides a Fourier series of analytical functions of position along said direction along which the structures are substantially periodic.

75. The method of claim 74, wherein said curve fitting process finds the best fit of the Fourier series to the data for determining a phase difference between data on the two structures..

76. The method of claim 72, said structures comprising an outer structure and an inner structure of boxes and/or bars, wherein said representing provides a first analytical function of radiation from the outer structure, and a second analytical function of radiation from the inner structure.

77. The method of claim 76, each of said outer and inner structures having a center, wherein said curve fitting process finds positions of the centers that provide the best fit of the first and second functions to data on the structures from the image.

78. The method of claim 77, wherein said determining includes comparing the two centers to find the overlay error.

79. The method of claim 76, wherein said representing provides a first pair of analytical functions of radiation from the outer structure, and a second pair of analytical functions of radiation from the inner structure, each of the two pairs of functions being a function of position along one of two axes x and y.

80. The method of claim 79, wherein each of the first and the second functions is of the form:

$$f(x) = \begin{cases} A_1 + \dfrac{B}{1+[(x-x_0)/d_1]^2}, x < x_0 \\ A_2 + \dfrac{B+(A_1-A_2)}{1+[(x-x_0)/d_2]^2}, x > x_0 \end{cases}$$

$$f(y) = \begin{cases} A_1 + \dfrac{B}{1+[(y-y_0)/d_1]^2}, y < y_0 \\ A_2 + \dfrac{B+(A_1-A_2)}{1+[(y-y_0)/d_2]^2}, y > y_0 \end{cases}$$

where A1, A2, B, x0, y0, d1, d2 are parameters that are altered in the curve fitting process, and where each of x0, y0 indicates location of an edge.

81. The method of claim 76, wherein each of the first and the second functions is an edge function indicative of radiation from an edge portion of the outer or inner structure.

82. The method of claim 76, wherein at least one of the first and second functions is a symmetric function.

83. The method of claim 72, wherein said process includes non-linear regression.

84. The method of claim 72, wherein said representing derives a one-dimensional signal from the image.

85. A computer readable storage device embodying a program of instructions executable by a computer to perform a method for determining overlay errors from a target having two structures, said method comprising:

providing a two-dimensional image of the target;

representing the image by at least one signal which is an analytical function of position in the image; and

determining an overlay error between the two structures using a curve fitting process of the at least one signal to data on the structures from the image.

86. The device of claim 85, each of said structures being periodic and having a pitch, wherein the representing provides a Fourier series of analytical functions of position along a direction along which the structures are periodic.

87. The device of claim 86, wherein said curve fitting process finds the best fit between the Fourier series and the data for determining a phase difference between the two structures.

88. The device of claim 86, said structures comprising an outer structure and an inner structure of boxes and/or bars, wherein said representing provides a first analytical function of radiation from the outer structure, and a second analytical function of radiation from the inner structure.

89. The device of claim 88, each of said outer and inner structures having a center, wherein said curve fitting process finds positions of the centers that provide the best fit between data on the structures from the image to the first and second functions.

90. The device of claim 89, wherein said determining includes comparing the two centers to find the overlay error.

91. The device of claim 88, wherein said representing provides a first pair of analytical functions of radiation from the outer structure, and a second pair of analytical functions of radiation from the inner structure, each of the two pairs of functions being a function of position along one of two axes x and y.

92. The device of claim 91, wherein each of the first and the second functions is of the form:

$$f(x) = \begin{cases} A_1 + \dfrac{B}{1+[(x-x_0)/d_1]^2}, x < x_0 \\ A_2 + \dfrac{B+(A_1-A_2)}{1+[(x-x_0)/d_2]^2}, x > x_0 \end{cases}$$

$$f(y) = \begin{cases} A_1 + \dfrac{B}{1+[(y-y_0)/d_1]^2}, y < y_0 \\ A_2 + \dfrac{B+(A_1-A_2)}{1+[(y-y_0)/d_2]^2}, y > y_0 \end{cases}$$

where A_1, A_2, B, x_0, y_0, d_1, d_2 are parameters that are altered in the curve fitting process, and where each of x_0, y_0 indicates location of an edge.

93 The device of claim 88, wherein each of the first and the second functions is an edge function indicative of radiation from an edge of the outer or inner structure.

94. The method of claim 88, wherein at least one of the first and second functions is a symmetric function.

95. The method of claim 85, wherein said representing derives a one-dimensional signal from the image.

96. A method for transmitting a program of instructions executable by a computer to perform a process for determining overlay errors from a target having two structures, said method comprising:

causing a program of instructions to be transmitted to a client device, thereby enabling the client device to perform, by means of such program, the following process:

providing a two-dimensional image of the target;

deriving at least one one-dimensional signal from the image; and

determining an overlay error from the at least one signal.

97. The method of claim 96, wherein said determining employs non-linear regression.

98. The method of claim 97, said process further comprising providing a model that provides parameter values wherein said regression matches the at least one signal to the parameter values provided by the model.

99. The method of claim 98, wherein said target comprises two gratings adjacent to each other periodic along substantially the same direction, said model providing parameter values for determining value(s) for the pitches of the gratings and a phase shift between them.

100. The method of claim 98 said model employing a fast Fourier transform algorithm.

101. The method of claim 96, said structures comprising boxes or bars, wherein said deriving derives two one-dimensional signal from the image in reference to two axes of the two-dimensional image.

102. The method of claim 96, said at least one one-dimensional signal being an analytical function.

103. The method of claim 96, said at least one one-dimensional signal being an edge function.

104. A method for transmitting a program of instructions executable by a computer to perform a process for determining overlay errors from a target having two structures, said method comprising:

causing a program of instructions to be transmitted to a client device, thereby enabling the client device to perform, by means of such program, the following process:

providing a two-dimensional image of the target;

representing the image by at least one signal which is an analytical function of position in the image; and

determining an overlay error between the two structures using a curve fitting process of the at least one signal to data on the structures from the image.

105. The method of claim 104, each of said structures being periodic and having a pitch, wherein the representing:

provides a one-dimensional signal corresponding to the pitch of each of the structures; and

deriving from said one-dimensional signal an altered one-dimensional signal corresponding to an average value of the pitches of the structures for each of the structures.

106. The method of claim 104, each of said structures being periodic and having a pitch, wherein the representing provides a Fourier series of analytical functions of position along a direction along which the structures are periodic.

107. The method of claim 106, wherein said curve fitting process finds the best fit between the Fourier series and the data for determining a phase difference between the two structures..

108. The method of claim 104, said structures comprising an outer structure and an inner structure of boxes and/or bars, wherein said representing provides a first analytical function of radiation from the outer structure, and a second analytical function of radiation from the inner structure.

109. The method of claim 108, each of said outer and inner structures having a center, wherein said curve fitting process finds positions of the centers that provide the best fit between data on the structures from the image and the first and second functions.

110. The method of claim 109, wherein said determining includes comparing the two centers to find the overlay error.

111. The method of claim 108, wherein said representing provides a first pair of analytical functions of radiation from the outer structure, and a second pair of analytical functions of radiation from the inner structure, each of the two pairs of functions being a function of position along one of two axes x and y.

112. The method of claim 111, wherein each of the first and the second functions is of the form:

$$f(x) = \begin{cases} A_1 + \dfrac{B}{1+[(x-x_0)/d_1]^2}, x < x_0 \\ A_2 + \dfrac{B+(A_1-A_2)}{1+[(x-x_0)/d_2]^2}, x > x_0 \end{cases}$$

$$f(y) = \begin{cases} A_1 + \dfrac{B}{1+[(y-y_0)/d_1]^2}, y < y_0 \\ A_2 + \dfrac{B+(A_1-A_2)}{1+[(y-y_0)/d_2]^2}, y > y_0 \end{cases}$$

where A_1, A_2, B, x_0, y_0, d_1, d_2 are parameters that are altered in the curve fitting process, and where each of x_0, y_0 indicates location of an edge.

113. The method of claim 108, wherein each of the first and the second functions is an edge function indicative of radiation from an edge portion of the outer or inner structure.

114. The method of claim 108, wherein at least one of the first and second functions is a symmetric function.

115. The method of claim 104, wherein said process includes non-linear regression.

116. The method of claim 104, wherein said representing derives a one-dimensional signal from the image.

117. An imaging method for detecting misalignment of two structures placed next to each other with respect to a reference plane, comprising:

providing a beam of radiation to illuminate the two structures;

collecting radiation from the two structures and directing the collected radiation to form an image of the two structures on an array of detectors, wherein said collecting collects radiation from the structures only along one or more directions away from any specular reflection direction(s) of the beam; and

determining a misalignment between the structures from outputs of the detectors.

118. The method of claim 117, wherein said determining includes finding a phase difference between outputs of the detectors.

119. The method of claim 117, wherein said providing provides a beam of radiation so that the beam illuminates the structures along directions that are substantially normal or near normal to the reference plane.

120. The method of claim 119, wherein the collecting collects radiation from the two structures along directions at oblique angles to the reference plane.

121. The method of claim 117, wherein said providing provides a beam of radiation so that the beam is at an oblique angle to the reference plane.

122. The method of claim 121, wherein the collecting collects radiation from the two structures along directions that are substantially normal or near normal to the reference plane.

123. The method of claim 117, wherein said providing provides a beam of radiation that illuminates the entire extent of both structures simultaneously.

124. The method of claim 117, each of said structures comprising an array of lines, said method further comprising summing the outputs of the detectors detecting radiation imaged onto the detectors from a line of one of the structures.

125. The method of claim 117, said two structures being periodic substantially along a direction, wherein said determining includes cross-correlating intensities of the radiation detected from adjacent lines of the two structures across at least two or more of the lines of each of the structures.

126. The method of claim 117, wherein said providing provides a laser beam or a broadband beam having multiple wavelengths.

127. The method of claim 126, wherein said providing provides a laser beam and said collecting collects radiation only along directions away from a specular reflection direction of the laser beam with respect to the reference plane.

128. An imaging apparatus for detecting misalignment of two structures placed next to each other with respect to a reference plane, comprising:

a source providing a beam of radiation illuminating the two structures;

an array of detectors;

optics collecting radiation from the two structures and directing the collected radiation to form images of the two structures on the array of detectors which provide outputs, said optics positioned to collect radiation only along directions away from a specular reflection direction of the beam with respect to the reference plane; and

a processor determining a misalignment between the structures from a phase difference between the outputs of the detectors.

129. The apparatus of claim 128, wherein said array includes a two dimensional array of detectors.

130. The apparatus of claim 128, wherein said source provides a beam of radiation so that the beam illuminates the structures along directions that are substantially normal or near normal to the reference plane.

131. The apparatus of claim 130, wherein the optics collects radiation from the two structures along directions at oblique angles to the reference plane.

132. The apparatus of claim 128, wherein said source provides the beam so that the beam is at an oblique angle to the reference plane.

133. The apparatus of claim 132, wherein the optics collects radiation from the two structures along directions that are substantially normal or near normal to the reference plane.

134. The apparatus of claim 128, wherein said source provides a beam of radiation that illuminates the entire extent of both structures simultaneously.

135. The apparatus of claim 128, each of said structures comprising an array of lines, said processor summing the outputs of the detectors detecting radiation imaged onto the detectors from a line of one of the structures.

136. The apparatus of claim 128, said two structures being periodic substantially along a direction, wherein said processor cross-correlates intensities of the radiation detected from adjacent lines of the two structures across at least two or more of the lines of each of the structures.

137. The apparatus of claim 128, wherein said source provides a laser beam or a broadband beam having multiple wavelengths.

138. The apparatus of claim 137, wherein said source provides a laser beam and said optics collects radiation only along directions away from a specular reflection direction of the laser beam with respect to the reference plane.

139. The apparatus of claim 128, wherein said optics includes a refractive element that directs radiation from the source to the two structures and that collects radiation from the two structures.

140. The apparatus of claim 139, said refractive element having a numerical aperture in the range of about 0.1 to 0.9.

141. The apparatus of claim 140, said refractive element having a numerical aperture in the range of about 0.4 to 0.8.

142. The apparatus of claim 141, said refractive element having a numerical aperture in the range of about 0.5 to 0.7.

143. The apparatus of claim 128, said detectors having an integration time less than about 10 milliseconds.